CERTIFICATION

I, Masami Sano, 26-10, Tenjin 2-chome, Nagaokakyo-shi, Kyoto-fu, Japan, do hereby certify that I am conversant with the English and Japanese language, and I further certify that to the best of my knowledge and belief that the attached English translation is a true and correct translation of the Japanese patent application No. JP2000-395515 filed on December 26, 2000.

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[Name of Document] SPECIFICATION

[Title of the Invention] SURFACE ACOUSTIC WAVE APPARATUS AND MANUFACTURING METHOD THEREFOR

[Claims]

[Claim 1] A manufacturing method for a surface acoustic wave apparatus to be mounted via bumps by a flip chip bonding system, comprising:

a step of preparing a piezoelectric substrate;

a step of forming a first electrode layer in which the first electrode layer of an electrode pad is formed on the piezoelectric substrate by etching;

a step of forming an electrode for surface acoustic wave element, in which the electrode for surface acoustic wave element is formed by a lift-off method, after the step of forming the first electrode layer;

a step of forming a second electrode layer of the electrode pad after the step of forming the electrode for surface acoustic wave element; and

a step of forming a wiring electrode for electrically connecting the electrode pad and the electrode for surface acoustic wave element.

[Claim 2] The manufacturing method for a surface acoustic wave apparatus according to Claim 1, wherein at least one electrode for a second surface acoustic wave element different from the electrode for surface acoustic wave

element is simultaneously formed with the first electrode layer in the step of forming the first electrode layer.

[Claim 3] The manufacturing method for a surface acoustic wave apparatus according to Claim 1 or Claim 2, wherein the wiring electrode is simultaneously formed with the second electrode layer.

[Claim 4] The manufacturing method for a surface acoustic wave apparatus according to any one of Claims 1 to 3, further comprising the step of forming an adhesive layer as a substrate prior to the formation of the wiring electrode and the second electrode layer, wherein the wiring electrode and the second electrode layer are made of Al or Al alloy, and the adhesive layer is made of metal or alloy having adhesion to the first electrode layer higher than that of Al or Al alloy.

[Claim 5] A surface acoustic wave apparatus to be mounted via bumps by a flip chip bonding system, comprising:

a piezoelectric substrate;

at least one electrode for surface acoustic wave element formed on the piezoelectric substrate;

an electrode pad which is formed on the piezoelectric substrate and is to be joined with the bump; and

a wiring electrode for electrically connecting the electrode pad and the electrode for surface acoustic wave element,

wherein the electrode pad comprises a first electrode layer formed on the piezoelectric substrate and a second electrode layer laminated on the first electrode layer, the first electrode layer is formed by etching of a metal film, and the electrode for surface acoustic wave element is formed by a lift-off method.

[Claim 6] The surface acoustic wave apparatus according to Claim 5, wherein the wiring electrode and the second electrode layer are integrally formed from the same metal film.

[Claim 7] The surface acoustic wave apparatus according to any one of Claim 5 or Claim 6, wherein an electrode for a second surface acoustic wave element different from the electrode for surface acoustic wave element is formed on the piezoelectric substrate, and the electrode for the second surface acoustic wave element is formed by etching of a metal film.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a manufacturing method for a surface acoustic wave apparatus to be mounted using metal bumps by a flip chip bonding system and to the surface acoustic wave apparatus. In particular, the present invention relates to a manufacturing method for a surface

acoustic wave apparatus in which at least one electrode for surface acoustic wave element is formed by a lift-off method and to the surface acoustic wave apparatus.

[0002]

[Description of the Related Art]

In recent years, in order to miniaturize surface acoustic wave apparatuses, the surface acoustic wave apparatuses assembled by a flip chip bonding system have been used widely. In this system, bumps made of Au, etc., are formed at electrode pads on a piezoelectric substrate constituting the surface acoustic wave apparatus, and the electrode pads and input and output electrode pads provided on the package or ground electrode pads are electrically connected via the bumps, and are mechanically joined at the same time.

[0003]

When the aforementioned flip chip bonding system is used, the bumps have not only a function of electrically connecting the surface acoustic wave apparatus and the package, but also a function of mechanically fixing the surface acoustic wave apparatus to the package. Therefore, it is required that the bumps themselves have a high strength, and in addition to this, the joining strength between the bumps and the electrode pads on the piezoelectric substrate is high, and the adhesion between

the electrode pads and the piezoelectric substrate is high.

[0004]

In order to increase the joining strength between the electrode pad and the bump, in general, a method, in which the thickness of the electrode pad is sufficiently increased, has been used. In order to increase the thickness of the electrode pad, a conventional method, in which a second electrode layer having a large film thickness is formed on a first electrode layer having a small film thickness, has been known.

[0005]

On the other hand, when the surface acoustic wave apparatus is formed, electrodes for surface acoustic wave element, for example, an interdegital transducer, reflector, and wiring electrodes, and the aforementioned electrode pads are formed on the piezoelectric substrate. When the electrode pad includes the first and second electrode layers, in many cases, the electrodes for surface acoustic wave element and the first electrode layer of the electrode pad are formed simultaneously. As the method for forming the electrode for surface acoustic wave element, (1) an etching method or (2) a lift-off method has been used. In (1) the etching method, a conductive film primarily containing Al is formed all over the surface of a substrate, and a desired resist pattern is formed by photolithography. Thereafter,

the resulting metal film is processed by wet etching or dry etching, and then, the resist is removed. In (2) the lift-off method, the metal film portion adhered on the resist is removed together with the resist and, therefore, the electrode is formed from the remaining metal film portion.

[0006]

In particular, regarding some surface acoustic wave filters for 800 MHz band or 1 to 2 GHz band, surface acoustic wave apparatuses are formed by the use of the aforementioned (2) lift-off method. An example of the method for manufacturing the aforementioned surface acoustic wave apparatus will now be described with reference to Figs. 10 to 12.

[0007]

As shown in Fig. 11(a), a resist pattern 102 is formed on a piezoelectric substrate 101 by photolithography. A metal film 103 primarily containing Al is formed on the piezoelectric substrate 101 as shown in Fig. 11(b). Subsequently, the resist pattern 102 is removed together with the metal film portion adhered thereon by lift-off. Thus, a first electrode layer 103a for constituting an electrode pad and an electrode for surface acoustic wave element 103b are simultaneously formed on the piezoelectric substrate 101 as shown in Fig. 11(c). Then, a resist pattern 104 is formed (Fig. 11(d)). A metal film 105 is

formed as shown in Fig. 12(a), and the resist pattern 105 is removed by performing the lift-off again. Consequently, as shown in Fig. 12(b), a second electrode layer 105a is formed on the first electrode layer 103a and, therefore, electrode pads 106 having a double-layer structure can be produced.

[0008]

Next, as shown in Fig. 10, bumps 107 are joined onto the electrode pads 106. A surface acoustic wave apparatus 108 is joined with a package by a flip chip bonding system using the bumps 107.

[0009]

[Problems to be Solved by the Invention]

In the case where the first electrode layer 103a of the electrode pad 106 was formed by the lift-off method as described above, since the adhesion between the piezoelectric substrate 101 and the first electrode layer 103a was relatively weak due to an affect of the resist used for the lift-off, when the formation was carried out using bumps 107 by a wire bumping method concurrently using ultrasonic waves and heat, sometimes, peeling occurred between the first electrode layer 103a and the piezoelectric substrate 101.

[0010]

Furthermore, when the surface acoustic wave apparatus 108 was mounted on the package by the flip chip bonding

system, and airtight sealing was performed by a covering member, sometimes cracks occurred in the piezoelectric substrate 101 in the neighborhood of the electrode pads 106 due to the mechanical stress brought about by the residual stress. Therefore, it was feared that the reliability, especially the reliability in the mechanical strength, of the surface acoustic wave apparatus was degraded.

[0011]

Accordingly, it is an object of the present invention to overcome the aforementioned problems in the conventional techniques, and to provide a manufacturing method for a surface acoustic wave apparatus having superior reliability, in which the adhesion between the electrode pad and the piezoelectric substrate is high, peeling of the electrode pad from the piezoelectric substrate is not likely to occur, and cracks are not likely to occur during the mounting on the package by the flip chip bonding system, regarding surface acoustic wave apparatuses to be assembled by a flip chip bonding system, as well as to provide a surface acoustic wave apparatus produced by the manufacturing method.

[0012]

[Means for Solving the Problems]

The present invention relates to a surface acoustic wave apparatus to be mounted via bumps by a flip chip bonding system. According to a wide aspect of the present

invention, a manufacturing method for the aforementioned surface acoustic wave apparatus is provided. The manufacturing method includes a step of preparing a piezoelectric substrate, a step of forming a first electrode layer in which the first electrode layer of an electrode pad is formed on the piezoelectric substrate by etching, a step of forming an electrode for surface acoustic wave element, in which the electrode for surface acoustic wave element is formed by a lift-off method, after the step of forming the first electrode layer, a step of forming a second electrode layer of the electrode pad after the step of forming the electrode for surface acoustic wave element, and a step of forming a wiring electrode for electrically connecting the electrode pad and the electrode for surface acoustic wave element.

[0013]

In a specific aspect of the manufacturing method according to the present invention, at least one electrode for a second surface acoustic wave element different from the aforementioned electrode for surface acoustic wave element is simultaneously formed with the first electrode layer in the step of forming the first electrode layer. In this case, since at least one electrode for the second surface acoustic wave element is formed by etching, the second electrode for surface acoustic wave element having a

thickness different from that of the electrode for surface acoustic wave element formed by the lift-off method can be formed with ease, and therefore, surface acoustic wave elements having different characteristics can be formed with ease on the piezoelectric substrate.

[0014]

In another specific aspect of the manufacturing method according to the present invention, the wiring electrode for electrically connecting the second electrode layer and the electrode for surface acoustic wave element are simultaneously formed with the second electrode layer. In this case, since the wiring electrode can be simultaneously formed with the second electrode layer, the reliability in the electrical connection between the electrode pad and the wiring electrode can be increased, and the simplification of the manufacturing steps can be achieved.

[0015]

In another specific aspect of the manufacturing method according to the present invention, the manufacturing method further include the step of forming an adhesive layer as a substrate prior to the formation of the wiring electrode and the second electrode layer, wherein the wiring electrode and the second electrode layer are made of Al or Al alloy, and the adhesive layer is made of metal or alloy having adhesion to the first electrode layer higher than that of Al or Al

alloy.

[0016]

By forming the aforementioned adhesive layer as the substrate layer, the adhesion of the second electrode layer to the first electrode layer can be further increased and, therefore, peeling of the electrode pad from the piezoelectric substrate and occurrence of cracks in the piezoelectric substrate during formation of the bumps and during mounting by the flip chip bonding system can be prevented further reliably.

[0017]

A surface acoustic wave apparatus according to the present invention includes a piezoelectric substrate, at least one electrode for surface acoustic wave element formed on the piezoelectric substrate, an electrode pad which is formed on the piezoelectric substrate and is to be joined with a bump, and a wiring electrode for electrically connecting the electrode pad and the electrode for surface acoustic wave element, wherein the electrode pad includes a first electrode layer formed on the piezoelectric substrate and a second electrode layer laminated on the first electrode layer, the first electrode layer is formed by etching of a metal film, and the electrode for surface acoustic wave element is formed by a lift-off method.

[0018]

In a specific aspect of the surface acoustic wave apparatus according to the present invention, the wiring electrode and the second electrode layer are integrally formed from the same metal film. In this case, the reliability in the electrical connection of the electrode pad and the wiring electrode can be increased, and the manufacturing steps can be simplified.

[0019]

In specific aspects of the surface acoustic wave apparatus according to the present invention, an electrode for a second surface acoustic wave element different from the aforementioned electrode for surface acoustic wave element is formed on the piezoelectric substrate, and the electrode for the second surface acoustic wave element is formed by etching of a metal film. When the electrode for the second surface acoustic wave element is formed by the etching method, it can be simultaneously formed with the first electrode layer of the electrode pad, and the film thickness thereof can be differentiated with ease from that of the electrode for surface acoustic wave element formed by the lift-off method. Therefore, surface acoustic wave elements having different characteristics can be formed with ease on the piezoelectric substrate.

[0020]

[Description of the Embodiments]

The present invention will be made clear by describing below specific embodiments according to the present invention with reference to the drawings.

[0021]

Fig. 1 is a sectional view of a surface acoustic wave apparatus according to a first embodiment of the present invention. Each of Fig. 2 to Fig. 4 is a sectional view for explaining the manufacturing method for the surface acoustic wave apparatus according to the first embodiment.

[0022]

Regarding the present embodiment, as shown in Fig. 2(a), a metal film 2 is formed all over the surface of a piezoelectric substrate 1. As the piezoelectric substrate 1, although not specifically limited, a piezoelectric single crystal, for example, $LiTaO_3$, $LiNbO_3$, or quartz, or a piezoelectric ceramic, for example, lead titanate zirconate ceramic, is used. In the present embodiment, the piezoelectric substrate 1 is composed of $LiTaO_3$. Although the metal film 2 is composed of an Al alloy in the present embodiment, it may be formed using other metal or alloy, for example, Cu. The metal film 2 is formed by vapor deposition of the Al alloy in the present embodiment. The thickness of the metal film 2 is not specifically limited, although it is usually specified to be about 5 to 500 nm. The method for forming the metal film 2 is not limited to the vapor

deposition, and the metal film 2 may be formed by plating, sputtering, or the like.

[0023]

Then, a resist pattern 3 corresponding to the shape of a first electrode layer of an electrode pad of a surface acoustic wave apparatus is formed by photolithography (Fig. 2(b)). The resist pattern 3 is formed from a publicly known photoresist material.

[0024]

The undesired part of the metal film 2 is removed by wet etching or dry etching (Fig. 2(c)).

The resist pattern 3 is removed by the use of a solvent. Consequently, as shown in Fig. 2(d), the first electrode layer 2a constituting the electrode pad is formed on the piezoelectric substrate 1.

[0025]

Thereafter, as shown in Fig. 3(a), a resist pattern 4 is formed by photolithography. The resist pattern 4 is applied to the region except where an electrode for surface acoustic wave element is formed.

[0026]

Subsequently, in order to form the electrode for surface acoustic wave element all over the top surface of the piezoelectric substrate 1, a metal film 5 is formed (Fig. 3(b)). In the present embodiment, the metal film 5 is made

of the Al alloy, and the film thickness thereof is usually specified to be within the range of 5 to 500 nm according to the frequency and bandwidth of the surface acoustic wave element.

[0027]

The electrode for surface acoustic wave element includes not only interdegital transducers, but also other electrodes which are electrodes other than electrode pads and function as surface acoustic wave elements, such as reflectors (not shown in the drawings) provided if necessary.

[0028]

Regarding the method for forming the metal film 5, although vapor deposition is carried out in the present embodiment, other thin film making methods, for example, sputtering and plating, may be carried out.

[0029]

Thereafter, the resist pattern 4 is removed by the lift-off method. As a result, an electrode for surface acoustic wave element 5a is formed on the piezoelectric substrate 1 as shown in Fig. 3(c).

[0030]

A resist pattern 6 is formed as shown in Fig. 3(d). The resist pattern 6 is applied to the region except where a second electrode layer of the electrode pad and a wiring electrode are formed.

[0031]

A metal film 7 is formed all over the surface of the piezoelectric substrate 1 as shown in Fig. 4(a). The metal film 7 is made of the Al alloy, and is formed by vapor deposition. However, it may be formed from other metal or alloy, for example, Cu, other than the Al alloy. Furthermore, the metal film 7 may be formed by plating, sputtering, or other thin film making method other than the vapor deposition.

[0032]

The thickness of the metal film 7 is specified to be larger than that of the first electrode layer 2a in consideration of the wiring resistance and the joining strength between the bump and the electrode pad. The thickness of the metal film 7 is usually specified to be within the range of 300 to 10,000 nm.

[0033]

Preferably, an adhesive layer 8 is formed as a substrate layer prior to the formation of the metal film 7, as shown in Fig. 9 under magnification. The metal film 7 is formed after the formation of the adhesive layer 8. The adhesive layer 8 is made of metal or alloy having adhesion higher than that of Al or Al alloy. The examples of the metal materials used for constituting the adhesive layer 8 include metals, for example, Ti, Ni, and a Ni-Cr alloy,

having adhesion to the piezoelectric substrate 1 and first electrode layer 2a higher than that of the metal film 7.

[0034]

Then, as shown in Fig. 4(b), the resist pattern 6 is removed by the lift-off method. Consequently, a second electrode layer 7a is formed, an electrode pad 9 composed of the first and second electrode layers 2a and 7a is formed, and at the same time, a wiring electrode 7b for electrically connecting the electrode pad 9 and an electrode for surface acoustic wave element 5a is formed.

[0035]

In the present embodiment, although the second electrode layer 7a and the wiring electrode 7b are simultaneously formed from the same metal material, while these are joining to each other, the wiring electrode 7b may be formed by a separate step.

Subsequently, bumps 10 are formed on the electrode pads 9 (refer to Fig. 1). Thus, a surface acoustic wave apparatus 11 shown in Fig. 1 is produced.

[0036]

The bumps 10 are formed by a wire bumping method concurrently using ultrasonic waves and heat, and the bumps 10 are formed from Au in the present embodiment.

The surface acoustic wave apparatus 11 produced as described above is contained in a package in order that the

top surface side shown in Fig. 1 is arranged as the bottom surface, that is, the bumps 10 are in contact with the electrode pads of the package, and therefore, an electrical and mechanical joining is achieved by the use of the bumps 10. Thereafter, the package is sealed airtight with a covering member, etc., so as to become a surface acoustic wave apparatus component.

[0037]

In the aforementioned conventional manufacturing method for surface acoustic wave apparatus, as is shown in Fig. 11, the first electrode layer 103a was formed by the lift-off method. In that case, since the resist pattern 102 was formed prior to the formation of the metal film 103, the top surface of the piezoelectric substrate 1 was inevitably soiled. Therefore, the adhesion of the first electrode layer 103a to the piezoelectric substrate 101 was likely to be degraded.

[0038]

In the surface acoustic wave apparatus 11 according to the present embodiment, the first electrode layer 2a constituting the electrode pad 9 is formed beforehand by the etching method. Therefore, since the metal film 2 is formed on the piezoelectric substrate 1 so as to intimately contact with it, and thereafter, the first electrode layer 2a is formed by etching, the adhesion of the first electrode layer

2a to the piezoelectric substrate 1 can be increased.

[0039]

Since the adhesion of the first electrode layer 2a to the piezoelectric substrate 1 is increased, peeling between the electrode pad 9 and the piezoelectric substrate 1 is not likely to occur, and occurrence of cracks in the piezoelectric substrate 1 can be prevented during the formation of the bumps 10. This will now be described using specific examples.

[0040]

In the examples, a surface acoustic wave apparatus in which the first electrode layer 2a is formed by wet etching, a surface acoustic wave apparatus in which the first electrode layer 2a is formed by dry etching, and for purposes of comparison, a surface acoustic wave apparatus in which the first electrode layer is formed by the conventional method as shown in Figs. 10 to 12 were produced separately. Regarding each of these surface acoustic wave apparatuses, the peeling rate of the electrode pad from the piezoelectric substrate and the crack occurrence rate in the piezoelectric substrate during the formation of the bump made of Au were examined. The results are shown in the following Table 1.

[0041]

The electrode pad peeling rate refers to a rate of

occurrence of peeling between the electrode pad and the piezoelectric substrate during the formation of the bump. The crack occurrence rate refers to a rate of surface acoustic wave apparatuses in which the cracks have occurred in the piezoelectric substrate in the neighborhood of the electrode pad relative to finished products. The crack occurs in the piezoelectric substrate in the neighborhood of the electrode pad due to mechanical stresses, such as a residual stress, and occurs depending on the materials and shapes of the bump, electrode pad, piezoelectric substrate, etc., in addition to the joining conditions during the flip chip bonding.

[0042]

Regarding the evaluation of the aforementioned electrode pad peeling rate and crack occurrence rate, the formation of the bumps was carried out by the wire bumping method concurrently using ultrasonic waves and heat. As the piezoelectric substrate, a 36° $LiTaO_3$ substrate was used. The thicknesses of the electrode for surface acoustic wave element and the first electrode layer were 200 nm, and the thicknesses of the second electrode layer and the wiring electrode were 840 nm. In each of the two kinds of surface acoustic wave apparatuses of the examples, a NiCr alloy layer of 10 nm in thickness was formed as an adhesive layer.

[0043]

In the conventional example, a plasma cleaning treatment was performed between the steps shown in Figs. 11(a) and 11(b), that is, before the vapor deposition of the metal film 103, and therefore, soils on the piezoelectric substrate 101 were removed. This method is commonly used as a method for helping increase adhesion between the first electrode layer 103a of the electrode pad and the piezoelectric substrate 101, and for reducing the aforementioned electrode pad peeling rate.

[0044]

[Table 1]

Electrode pad forming process	Electrode peeling rate during bump formation (%)	Crack occurrence rate (%)
Wet process	0%	0%
Dry process	0%	0%
Lift-off process	0.5% to 1.0%	12%

[0045]

As is clear from Table 1, regarding the conventional manufacturing method for surface acoustic wave apparatus, in spite of application of the aforementioned plasma cleaning, the electrode pad peeling rate was 0.5 to 1.0%, and the crack occurrence rate was 12%. On the other hand, regarding either of the case where the wet etching and dry etching were used, the electrode pad peeling rate and the crack occurrence rate were 0 when the manufacturing method according to the present embodiment was applied.

[0046]

The reasons for this are believed to be that regarding the conventional method, (1) since the piezoelectric substrate is coated with the resist by the lift-off process, the first electrode layer cannot be formed on the piezoelectric substrate with high adhesion strength even when the plasma cleaning treatment is applied, and (2) in the lift-off process, when the metal film made of Al is formed, there are limitations in the film making conditions, for example, the film making temperature must be specified in consideration of the heat resistance of the resist, and consequently, properties of the electrode film, for example, hardness of the electrode layer, are varied and, therefore, peeling of the electrode pad and occurrence of the cracks are likely to be brought about.

[0047]

Each of Fig. 5 to Fig. 8 is a sectional view for explaining the manufacturing method for the surface acoustic wave apparatus according to the second embodiment. In the second embodiment, a surface acoustic wave apparatus shown in Fig. 5 is produced finally.

[0048]

As shown in Fig. 6(a), a metal film 22 is formed all over the surface of the piezoelectric substrate 21 by vapor deposition. This step is carried out in a manner similar to

that in the case where the metal film 2 is formed on the piezoelectric substrate 1 in the first embodiment.

[0049]

Then, as shown in Fig. 6(b), a resist pattern 23 is formed by photolithography. In the second embodiment, two surface acoustic wave elements are formed on the piezoelectric substrate 21. The resist pattern 23 is formed in order to locate on the portion where an electrode for a first surface acoustic wave element is to be formed and on the portion where the first electrode layer of the electrode pad is to be formed.

[0050]

The metal film 22 is etched by dry etching or wet etching (Fig. 6(c)).

The resist pattern 23 is removed. Thus, the first electrode layer 22a for constituting an electrode pad and the electrode for the first surface acoustic wave element 22b are formed on the piezoelectric substrate 21 as shown in Fig. 6(d).

[0051]

Subsequently, as shown in Fig. 7(a), a resist pattern 24 is formed. The resist pattern 24 is formed on the portion except where an electrode for a second surface acoustic wave element is formed. A metal film 25 is formed all over the top surface of the piezoelectric substrate 21

(Fig. 7(b)).

[0052]

The resist pattern 24 and the metal film adhered thereon are removed by the lift-off method. Thus, the electrode for the second surface acoustic wave element 25a is formed by the lift-off method as shown in Fig. 7(c).

[0053]

A resist pattern 26 is formed as shown in Fig. 7(d). The resist pattern 26 is applied on the portion except where a second electrode layer and a wiring electrode are formed.

[0054]

A metal film 27 is formed all over the top surface of the piezoelectric substrate 21 as shown in Fig. 8(a). This metal film 27 is formed from a material similar to that of the metal film 7 in the first embodiment, and has a thickness nearly equivalent to that of the metal film 7.

[0055]

The resist pattern 26 and the metal film portion adhered thereon are removed by the lift-off method as shown in Fig. 8(b). Thus, a second electrode pad 27a and a wiring electrode 27b are formed. The wiring electrode 27b is simultaneously formed with the second electrode layer 27a while being joined to the second electrode layer 27a.

[0056]

An electrode pad 28 is composed of the aforementioned

second electrode layer 27a and the first electrode layer 22a formed beforehand.

Subsequently, bumps 29 are formed on the electrode pads 28 and, therefore, a surface acoustic wave apparatus 31 shown in Fig. 5 is produced.

[0057]

In the surface acoustic wave apparatus 31 as well, since the first electrode layer 22a of the electrode pad is formed on the piezoelectric substrate 21 by etching, the adhesion between the electrode pad and the piezoelectric substrate can be increased in a manner similar to that in the first embodiment.

[0058]

In addition to this, since the electrode for the first surface acoustic wave element 22b and the electrode for the second surface acoustic wave element 25a are formed by the etching method and lift-off method, respectively, the film thicknesses of these electrodes can be differentiated with ease, and a plural kinds of surface acoustic wave elements having different bands can be thereby formed with ease on the piezoelectric substrate 21. That is, dual filters having different bands, etc., can be realized with ease.

[0059]

Although in the aforementioned embodiments, the electrode for surface acoustic wave element and the

electrode pads are formed in order to constitute one surface acoustic wave apparatus on each of the piezoelectric substrates 1 and 21, usually, electrodes for surface acoustic wave element and electrode pads of a plurality of surface acoustic wave apparatuses are formed on a mother piezoelectric substrate according to each of the aforementioned embodiments, and finally, an individual surface acoustic wave apparatus is produced by dicing or other method for division.

[0060]

In the present invention, the configuration of the electrode for surface acoustic wave element is not specifically limited, and the present invention can be applied to manufacture not only surface acoustic wave filters, but also various surface acoustic wave apparatuses, such as surface acoustic wave resonators and surface acoustic wave delay lines.

[0061]

[Advantages]

In the manufacturing method for surface acoustic wave apparatus according to the present invention, the first electrode layer of the electrode pad is formed on the piezoelectric substrate by etching, and then, the electrode for surface acoustic wave element is formed by the lift-off method after the step of forming the first electrode layer.

Subsequently, the second electrode layer of the electrode pad is formed on the first electrode layer. Therefore, since the first electrode layer is formed on the clean piezoelectric substrate not soiled by photolithography residue, etc., the adhesion between the electrode pad and the piezoelectric substrate can be increased effectively. In addition, the electrode pad has a structure in which the first and second electrode layers are laminated. Consequently, peeling between the electrode pad and the piezoelectric substrate is not likely to occur during the formation of the bumps or during the mounting of the surface acoustic wave apparatus into the package by the flip chip bonding system via the bumps. Likewise, cracks in the piezoelectric substrate in the neighborhood of the electrode pad are not likely to occur.

[0062]

Therefore, the surface acoustic wave apparatus having superior reliability can be produced.

Likewise, in the surface acoustic wave apparatus according to the present invention, since the first electrode layer of the electrode pad is formed by etching of the metal film, the electrode for surface acoustic wave element is formed by the lift-off method, and the electrode pads are formed by laminating the first and second electrode layers, by using the manufacturing method for surface

acoustic wave apparatus according to the present invention, peeling of the electrode pad from the piezoelectric substrate and occurrence of cracks in the piezoelectric substrate due to the external force applied during the formation of the bumps and during the mounting into the package by the flip chip bonding system, etc., can be prevented reliably.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a sectional front view of a surface acoustic wave apparatus according to a first embodiment of the present invention.

[Fig. 2]

Each of Figs. 2(a) to 2(d) is a sectional front view for explaining the step in the manufacture of the surface acoustic wave apparatus according to the first embodiment.

[Fig. 3]

Each of Figs. 3(a) to 3(d) is a sectional front view for explaining the step in the manufacture of the surface acoustic wave apparatus according to the first embodiment.

[Fig. 4]

Each of Figs. 4(a) and 4(b) is a sectional front view for explaining the step in the manufacture of the surface acoustic wave apparatus according to the first embodiment.

[Fig. 5]

Fig. 5 is a sectional front view of a surface acoustic wave apparatus according to a second embodiment of the present invention.

[Fig. 6]

Each of Figs. 6(a) to 6(d) is a sectional front view for explaining the step in the manufacture of the surface acoustic wave apparatus according to the second embodiment.

[Fig. 7]

Each of Figs. 7(a) to 7(d) is a sectional front view for explaining the step in the manufacture of the surface acoustic wave apparatus according to the second embodiment.

[Fig. 8]

Each of Figs. 8(a) and 8(b) is a sectional front view for explaining the step in the manufacture of the surface acoustic wave apparatus according to the second embodiment.

[Fig. 9]

Fig. 9 is a sectional front view of a part of a preferable modified example based on the first embodiment.

[Fig. 10]

Fig. 10 is a sectional front view for explaining a conventional surface acoustic wave apparatus.

[Fig. 11]

Each of Figs. 11(a) to 11(d) is a sectional front view for explaining the step in the manufacture of the conventional surface acoustic wave apparatus shown in Fig.

10.

[Fig. 12]

Each of Figs. 12(a) and 12(b) is a sectional front view for explaining the step in the manufacture of the conventional surface acoustic wave apparatus shown in Fig. 10.

[Reference Numerals]

1: piezoelectric substrate

2: metal film

2a: first electrode layer

3: resist pattern

4: resist pattern

5: metal film

5a: electrode for surface acoustic wave element

6: resist pattern

7: metal film

7a: second electrode layer

7b: wiring electrode

8: adhesive layer

9: electrode pad

10: bump

11: surface acoustic wave apparatus

21: piezoelectric substrate

22: metal film

22a: first electrode layer

22b: electrode for surface acoustic wave element

23: resist pattern

24: resist pattern

25: metal film

25a: electrode for surface acoustic wave element

26: resist pattern

27: metal film

27a: second electrode layer

27b: wiring electrode

28: electrode pad

29: bump

31: surface acoustic wave apparatus

JP Application No. 2000-395515

[Name of Document] ABSTRACT

[Abstract]

[Object] A manufacturing method for surface acoustic wave apparatus to be mounted via bumps by a flip chip bonding system is provided, in which peeling of electrode pads from the piezoelectric substrate and cracks in the piezoelectric substrate are not likely to occur during the formation of the bumps, etc.

[Solving Means] A manufacturing method for surface acoustic wave apparatus in which a first electrode layer 2a of the electrode pad is formed on a piezoelectric substrate 1 by etching, an electrode for surface acoustic wave element 5a is formed by a lift-off method after the first electrode layer 2a is formed, and thereafter, an electrode film including a second electrode layer 7a of the electrode pad and a wiring electrode 7b is formed.

[Selected Figure] Fig. 1